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# THE TRANSFER OF CONTEXTUAL CONTROL OVER EQUIVALENCE CLASSES THROUGH EQUIVALENCE CLASSES: A POSSIBLE MODEL OF SOCIAL STEREOTYPING

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In Experiment 1, subjects acquired conditional equivalence classes controlled by three male and three female names as contextual stimuli. When equivalence relations were tested using new names not used in training (three male and three female), contextual control remained intact. Thus, generalized control of the composition of conditional equivalence classes by characteristically gender-identified names was shown. A basic analysis of this finding was tested in Experiment 2. Contextual equivalence classes were established using as contextual stimuli nonrepresentational visual figures that were members of additional pretrained three-member equivalence classes. When other stimuli in the pretrained equivalence classes were used as contextual stimuli, the conditional equivalence classes remained intact. Control subjects showed that this effect depended on the equivalence relations established in pretraining. The results show that contextual control over equivalence classes can transfer through equivalence classes. The implications of this phenomenon for social stereotyping are discussed.

*Key words:* stimulus equivalence, conditional equivalence classes, transfer of functions, sexism, social stereotyping, matching to sample, humans

Stimulus equivalence has captured the attention of many behavior-analytic researchers because of its apparent relevance to language phenomena such as word–referent relations (S. Hayes & L. Hayes, 1989), language training (e.g., Gast, VanBiervliet, & Spradlin, 1979; Sidman, 1971) and rule governance (S. Hayes, 1989b; L. Hayes, Thompson, & S. Hayes, 1989). Two phenomena are particularly relevant to the application of stimulus equivalence to natural language: the formation of conditional equivalence classes and the transfer of functions through equivalence classes.

Conditionality is necessary for equivalence to serve as a preliminary model of verbal stimulation because it provides for the necessary precision seen in language. For example, the meaning of the word *gay* could be either *happy* or *homosexual,* depending in part on the context in which it occurred. Several studies have demonstrated conditional equivalence relations (e.g., Bush, Sidman, & de Rose, 1989; Kennedy & Laitinen, 1988; Wulfert & Hayes, 1988).

Contextual control over equivalence classes has been demonstrated with such stimuli as tones (Bush et al., 1989), shapes (Kennedy & Laitinen, 1988), and background colors (Wulfert & Hayes, 1988). In natural language, however, contextual control over word meaning is typically supplied by other words. For example, compare the different meanings of the word *bat* in the following sentences: "Babe Ruth held the bat firmly" and "Dracula held the bat firmly." In this example, *bat* is in an equivalence relation with a piece of wood or a flying mammal, depending upon other words (*Babe Ruth* or *Dracula,* respectively) as contextual stimuli.

The difference between verbal control over equivalence relations and control by nonarbitrary contextual cues is important. In the latter case, generalization can occur across formal properties of the contextual stimuli such as color, shape, and the like (e.g., Honig & Urcuioli, 1981; Keller & Schoenfeld, 1950). When verbal stimuli are involved, however, their formal features rarely provide a basis for generalization. Instead, transfers of function occur on thematic grounds (Skinner, 1957). For example, for most listeners "Don Drysdale held the bat" is more likely to evoke a bat-class similar to the one evoked by *Babe Ruth* than the one evoked by *Dracula,* despite the greater formal similarity between *Drysdale* and *Dracula.*

In the present studies, we examined the idea that verbal control of equivalence relations may

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Table 1

Experiment 1: training and testing trials. The correct comparison is the first stimulus to appear after the sample (the sample appears in bold face). The positions of the comparison stimuli were counterbalanced throughout all phases of the experiment.

| | | | | |
|---|---|---|---|---|
| Phase 1: conditional discrimination training | | | | |
| A-B relations: | CS-male: | **A1**: B1 B2 B3 | **A2**: B2 B1 B3 | **A3**: B3 B1 B2 |
| | CS-female: | **A1**: B1 B2 B3 | **A2**: B2 B1 B3 | **A3**: B3 B1 B2 |
| A-C relations: | CS-male: | **A1**: C1 C2 C3 | **A2**: C2 C1 C3 | **A3**: C3 C1 C2 |
| | CS-female: | **A1**: C3 C2 C1 | **A2**: C1 C2 C3 | **A3**: C2 C1 C3 |
| A-D relations: | CS-male: | **A1**: D1 D2 D3 | **A2**: D2 D1 D3 | **A3**: D3 D1 D2 |
| | CS-female | **A1**: D3 D2 D1 | **A2**: D1 D2 D3 | **A3**: D2 D1 D3 |
| Mixed A-B, A-C, A-D training: All of the above trials were randomly presented. | | | | |
| Phase 2: conditional symmetry and equivalence testing | | | | |
| Symmetry: The trials depicted below were randomly presented. | | | | |
| B-A relations: | CS-male: | **B1**: A1 A2 A3 | **B2**: A2 A1 A3 | **B3**: A3 A1 A2 |
| | CS-female: | **B1**: A1 A2 A3 | **B2**: A2 A1 A3 | **B3**: A3 A1 A2 |
| C-A relations: | CS-male: | **C1**: A1 A2 A3 | **C2**: A2 A1 A3 | **C3**: A3 A1 A2 |
| | CS-female: | **C1**: A2 A1 A3 | **C2**: A3 A2 A1 | **C3**: A1 A2 A3 |
| D-A relations: | CS-male | **D1**: A1 A2 A3 | **D2**: A2 A1 A3 | **D3**: A3 A1 A2 |
| | CS-female: | **D1**: A2 A1 D3 | **D2**: A3 A1 A2 | **D3**: A1 A2 A3 |
| Equivalence: The trials depicted below were randomly presented. | | | | |
| B-C relations: | CS-male: | **B1**: C1 C2 C3 | **B2**: C2 C1 C3 | **B3**: C3 C1 C2 |
| | CS-female: | **B1**: C3 C1 C2 | **B2**: C1 C2 C3 | **B3**: C2 C1 C3 |
| C-B relations: | CS-male: | **C1**: B1 B2 B3 | **C2**: B2 B1 B3 | **C3**: B3 B1 B2 |
| | CS-female: | **C1**: B3 B1 B2 | **C2**: B1 B2 B3 | **C3**: B2 B1 B3 |
| B-D relations: | CS-male: | **B1**: D1 D2 D3 | **B2**: D2 D1 D3 | **B3**: D3 D1 D2 |
| | CS-female: | **B1**: D3 D2 D1 | **B2**: D1 D2 D3 | **B3**: D2 D1 D3 |
| D-B relations: | CS-male: | **D1**: B1 B2 B3 | **D2**: B2 B1 B3 | **B3**: B3 B1 B2 |
| | CS-female: | **D1**: B3 B2 B1 | **D2**: B1 B2 B3 | **B3**: B2 B1 B3 |
| C-D relations: | CS-male: | **C1**: D1 D2 D3 | **C2**: D2 D1 D3 | **C3**: D3 D1 D2 |
| | CS-female: | **C1**: D1 D2 D3 | **C2**: D2 D1 D3 | **C3**: D3 D1 D2 |
| D-C relations | CS-male: | **D1**: C1 C2 C3 | **D2**: C2 C1 C3 | **D3**: C3 C1 C2 |
| | CS-female: | **D1**: C1 C2 C3 | **D2**: C2 C1 C3 | **D3**: C3 C1 C2 |
| Phase 3: transfer of function test | | | | |
| All symmetrical and equivalence relations above were presented, using novel contextual stimuli (CS-male, CS-female). | | | | |

provide a preliminary model of social stereotyping. Consider the sentences "the woman complained and complained" and "the man complained and complained." The word *woman* in the first sentence may serve as a context in which words like *nag* or *bitch* are related to the word *complain*. The word *man* in the second sentence may serve to relate *complain* with *assertive* or *forceful*. Our biases about sexual, racial, religious, and other groups might be described in part as a matter of contextual control over verbal relations.

Experiment 1 examined these issues by assessing the transfer of contextual control over equivalence along a previously established verbal dimension. The verbal dimension used was gender-identified names.

## EXPERIMENT 1

### METHOD

*Subjects*

Six introductory psychology students (2 males and 4 females) completed Experiment 1 for course credit. Subjects could decline to participate at any time. Eight subjects began the study; 2 of them withdrew due to time demands (neither had yet reached the crucial transfer test phase).

*Apparatus and Stimulus Materials*

Sessions were conducted in a small room, with subjects seated at a table on which was placed a color computer monitor and a keyboard. The stimuli consisted of arbitrary, non-

representational visual figures, approximately 6 cm in diameter (see S. Hayes, Kohlenberg, & L. Hayes, 1991, for examples).

*General Experimental Sequence*

There were three phases to this experiment. In Phase 1, subjects were provided with the conditional discrimination training necessary to form six four-member conditional equivalence classes. The contextual stimuli used in training consisted of one of six names (three male, three female). During Phase 2, subjects received a symmetry test and then an equivalence test, both with the contextual stimuli used in training. Phase 3 consisted of a test for symmetrical and equivalence relations given each of three female and three male names that had *not* been used in training. The trained and tested relations and the contextual stimuli are depicted in Figure 1. The training and testing trials and procedural sequences are shown in Table 1.

*Procedure*

*Matching to sample.* All instructions appeared on the computer monitor. The subjects were instructed to "note the symbol at the top and then choose a symbol from the bottom" (for complete instructions see S. Hayes et al., 1991).

The task was presented as follows. The sample appeared in the center of the top half of the computer screen, in a 7-cm box drawn by a 0.25-cm red line. Two seconds after the sample appeared, and while it remained on the screen, three comparison stimuli appeared in 7-cm red boxes at the bottom of the screen along with the contextual stimulus, which appeared in the upper left corner of the computer screen. The contextual stimuli consisted of written words, which were approximately 3 cm by 2 cm.

Subjects selected a comparison stimulus by pressing one of three color-coded keys on the computer keyboard. The three keys were situated on the left, middle, and right of the keyboard, corresponding with the positions of the three comparison stimuli on the screen. When the key on the right was pressed, the comparison stimulus on the right of the computer screen was selected; when the key in the middle was pressed, the middle comparison stimulus was selected, and so on. When a key was pressed, a blinking white box was drawn

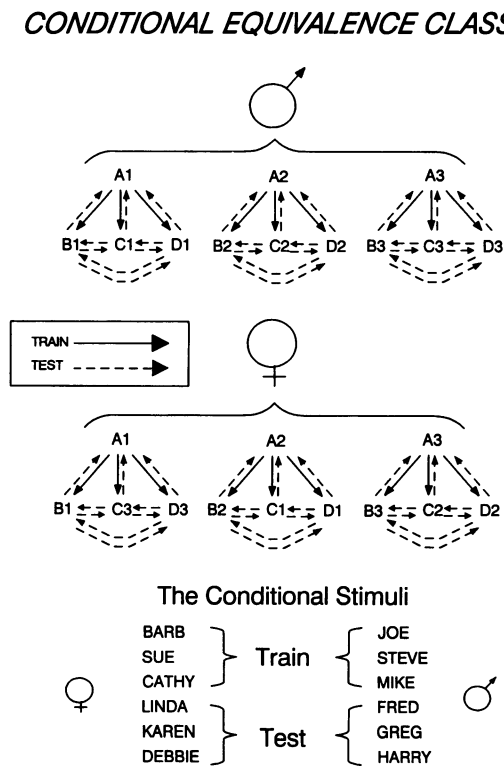


Fig. 1. A diagram of the procedure used in Experiment 1.

around the selected comparison for 2 s. The subject confirmed a selection by pressing the enter key. To show that a selection had been confirmed, the blinking white box blinked more rapidly for 0.5 s, and a series of staccato notes were sounded. If the enter key was not pressed before the box stopped blinking, a new comparison could then be selected.

During training (Phase 1), when the subject made a selection, the word "correct" or "incorrect" appeared in the upper right corner of the screen, along with a sequence of two tones (ascending or descending, respectively). During testing no feedback was given. During all phases of training, during symmetry testing, and during the first phase of conditional equivalence testing, a criterion of 90% correct responses was required before moving from one phase to the next.

Prior to the actual experiment, subjects were trained to engage in the selection response through instructions and feedback, which appeared on the computer screen. No experimental stimuli were present during this training.

*Phase 1: Conditional discrimination training.* During Phase 1, subjects were presented with a total of 18 conditional discriminations. Nine of these discriminations appeared with three male names as the contextual stimuli, and the remaining nine discriminations appeared with three female names. These names were presented in a random order, such that each specific name appeared three times per 18-trial training block. Male and female contextual stimuli will hereafter be referred to as CS-male and CS-female, respectively. The subjects received training necessary to form six four-member conditional equivalence classes—(CS-male): A1, B1, C1, D1; A2, B2, C2, D2; and A3, B3, C3, D3; and (CS-female): A1, B1, C3, D3; A2, B2, C1, D1; and A3, B3, C2, D2.

*A-B training.* In the first part of Phase 1, AB relations were trained sequentially in 18-trial blocks as follows: (CS-male): A1-B1, A2-B2, A3-B3; or (CS-female): A1-B1, A2-B2, A3-B3. The subject proceeded to each new problem after reaching criterion on the previous problem. After reaching criterion for each A-B relation, all A-B relations were mixed and trained to criterion in 18-trial blocks (in all phases of both experiments, mixed training blocks presented component problems in random order, but for an equal number of times). Upon meeting criterion within an 18-trial block (90% correct, or no more than one error), A-C relations were trained.

*A-C training.* A-C relations ([CS-male]: A1-C1, A2-C2, A3-C3; [CS-female]: A1-C3, A2-C1, A3-C2) were then trained. The training procedure was identical to that used to train the A-B relations. Upon reaching criterion, A-D relations were trained.

*A-D training.* A-D relations ([CS-male]: A1-D1, A2-D2, A3-D3 and [CS-female]: A1-D3, A2-D1, A3-D2) were then trained. When criterion was reached, the subject was then presented with all A-B, A-C, and A-D relations.

*A-B, A-C, A-D training.* All A-B, A-C, and A-D training trials were randomly presented in 54-trial blocks until criterion was reached. Upon reaching criterion, subjects then moved to Phase 2.

*Phase 2: Testing for derived relations.* Prior to beginning any testing phase, the following instructions appeared on the computer screen: "In this phase you will not receive feedback." During testing phases, the screen appearance and method of stimulus selection were as described in the training phase, except that no feedback was delivered.

*Symmetry testing.* Subjects first received an 18-trial conditional symmetry test covering all B-A, C-A, and D-A relations ([CS-male]: B1-A1, B2-A2, B3-A3; [CS-female]: B1-A1, B2-A2, B3-A3); ([CS-male]: C1-A1, C2-A2, C3-A3; [CS-female]: C1-A2, C2-A3, C3-A1); ([CS-male]: D1-A1, D2-A2, D3-A3; [CS-female]: D1-A2, D2-A3, D3-A1). If criterion was not met during this phase, the subject repeated the last training phase (randomly presented A-B, A-C, A-D trials) and remained in that phase until meeting criterion. The subject then was presented with the symmetry test once again. If criterion was not met, the subject again repeated the last training phase. This recycling procedure could occur indefinitely until criterion was met. Once criterion was met on the test of symmetrical relations, the subject was presented with a 36-trial conditional equivalence test.

*Conditional equivalence testing.* Subjects were presented with a 36-trial conditional equivalence test covering all B-C, C-B, B-D, D-B, C-D, and D-C relations. The contextual stimuli (male and female names) were the same names employed in the training phase. If criterion was not reached within the 36-trial block, the subject repeated the mixed conditional A-B, A-C, and A-D training phase. When criterion was reached in the training phase, the subject was presented with the symmetry test, and upon reaching criterion, the equivalence test was repeated. Upon reaching criterion in Phase 2, the subject moved to Phase 3.

*Phase 3: Transfer of contextual control to new names.* Phase 3 consisted of a 54-trial presentation of all symmetrical and equivalence relations. The contextual stimuli, however, consisted of any one of three novel female and three novel male names (see Figure 1). The individual names were sequenced randomly and were used an equal number of times.

## Results and Discussion

Of the 2 subjects who chose to withdraw, 1 failed to finish Phase 1 and 1 failed to finish Phase 2. The results from the other 6 subjects are shown in Figures 2 and 3. There was considerable variability in the acquisition of the conditional discriminations. The number

of trials required before reaching criterion ranged from 270 to 828.

Subjects 1 through 4 met criterion immediately on the symmetry test. Subjects 5 and 6 each required retraining with the conditional discriminations prior to meeting criterion. Subject 1 met criterion immediately on the equivalence test, and Subjects 2 through 6 required one, one, one, three, and five retests, respectively, before reaching criterion on the equivalence test.

The crucial part of Experiment 1 was Phase 3, which tested the control over conditional equivalence classes by novel sexually typed names. Subjects 1 through 4 and 6 met criterion upon their first exposure to the 54-trial symmetry and equivalence test. Subject 5 did not meet criterion until having had a second exposure to the test, after having been retrained and then retested in Phase 2.

Thus, Experiment 1 shows that contextual control over equivalence relations transferred through preexisting verbal classes: male and female names. Equivalence may be one way that this transfer of contextual control took place. It seems plausible that each female and each male name could have become related to "female" or "male" through direct training and were related to each other indirectly via derived relations. Because we do not have access to the training history that might be involved in such a process, we modeled such a history in Experiment 2. Experiment 2 assessed whether contextual control *over* an equivalence class could be transferred *through* an equivalence class.

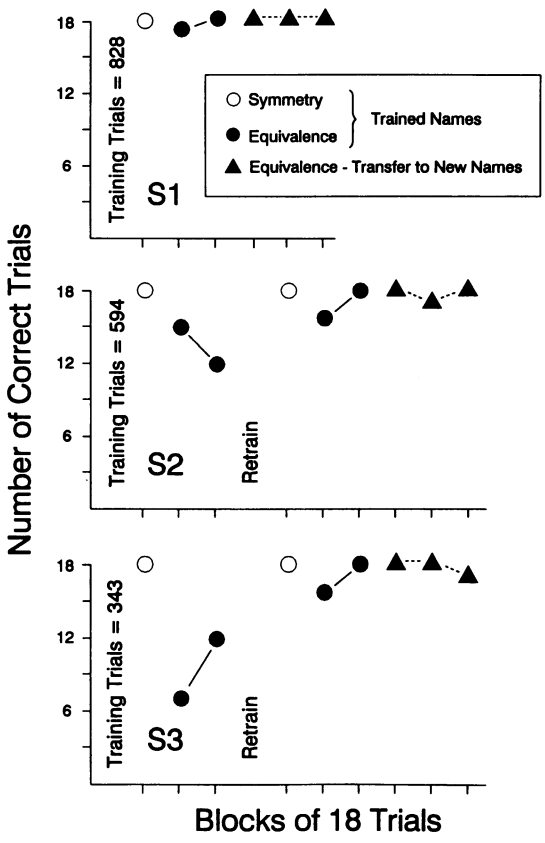


Fig. 2. The results for Subjects 1 through 3. The open circles refer to the symmetry tests on the trained conditional equivalence classes, the closed circles to the equivalence tests for those classes, and the closed triangles to the symmetry and equivalence performance using the novel conditional stimuli.

A previous study has examined the transfer of control over equivalence classes through equivalence classes (Gatch & Osborne, 1989). Unfortunately, it contained a common methodological limitation. With a few exceptions (S. Hayes, Devany, Kohlenberg, Brownstein, & Shelby, 1987; S. Hayes et al., 1991; Wulfert & Hayes, 1988), all studies to date on the transfer of stimulus functions through equivalence classes have tested the transfer of functions from samples to directly paired comparisons (Catania, Horne, & Lowe, 1989; Gatch & Osborne, 1989; Lazar, 1977; Lazar & Kotlarchyk, 1986). For example, in the Gatch and Osborne study, contextual control over equivalence class composition was trained to a stimulus we will call A1. A1-B1 and A1-C1 relations were then trained and the contextual control exerted by B1 and C1 was assessed. The A-B, A-C, C-A, or B-A relations are not equivalence relations in the definitional sense identified by Fields, Verhave, and Fath (1984), although they may be part of an equivalence class. The transfer of functions between these directly paired stimuli at best would require only symmetry. Further, because there were direct reinforced pairings of the crucial stimuli, direct associative processes (e.g., stimulus compounding) could be involved in the transfer seen. Conversely, some stimulus relations in an equivalence class test neither reflexivity, symmetry, nor transitivity alone, but are instead "a combined test for the three required properties of equivalence" (Sidman, 1990, p. 102). Because they serve as combined tests, a better transfer-of-function strategy is to ex-

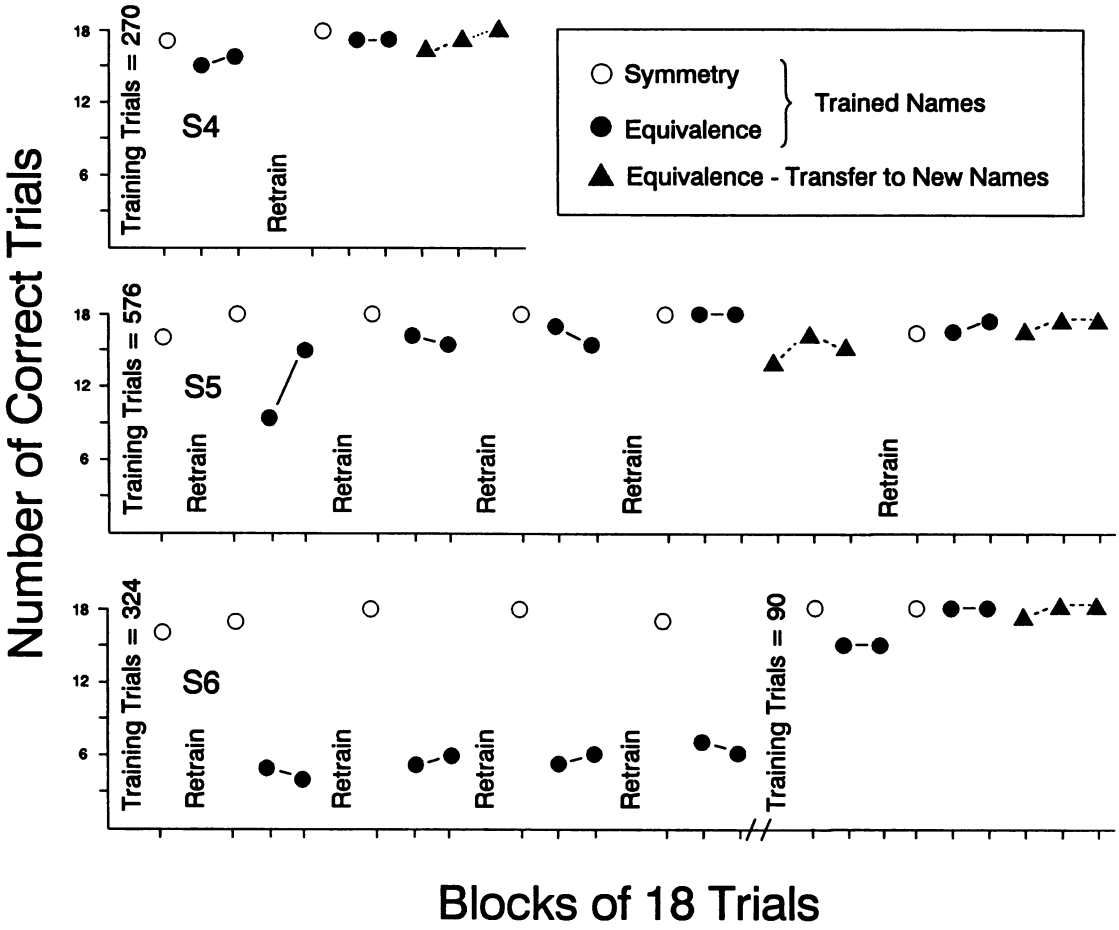


Fig. 3. The results for Subjects 4 through 6. The open circles refer to the symmetry tests on the trained conditional equivalence classes, the closed circles to the equivalence tests for those classes, and the closed triangles to the symmetry and equivalence performance using the novel conditional stimuli.

amine the transfer of functions through these kinds of relations. For example, using Gatch and Osborne's trained relations (A-B, A-C), contextual control should have been established with the B stimuli and tested with the C stimuli. The relation between B and C stimuli in such a network is entirely indirect and is an equivalence relation (Fields et al., 1984). This was the strategy we followed in Experiment 2.

## EXPERIMENT 2

### METHOD

*Subjects*

Six students in introductory psychology (3 males and 3 females) completed Experiment 2 for course credit. Subjects were initially solicited for two 2-hr blocks of time. One subject not meeting criterion during the training phase was not asked to continue. All others were asked, but 6 declined—of these, 3 had been tested at least once in Phase 3 before terminating (their data are shown later), and the remaining 3 had learned the conditional discriminations but had failed to acquire conditional equivalence classes.

*General Experimental Sequence*

During Phase 1 (pretraining), all subjects received the conditional discrimination training and testing necessary to establish three three-member equivalence classes. We will term these "pretraining equivalence classes." For the experimental subjects the classes were

A1, B1, C1; A2, B2, C2; and A3, B3, C3. For control subjects they were A1, B1, X1; A2, B2, C2; and A3, B3, X3 (that is, the C1 and C3 stimuli were different from those used with the experimental subjects). In Phase 2, the B stimuli from two of the pretraining equivalence classes were used as contextual stimuli in conditional discrimination training necessary to form six three-member conditional equivalence classes composed of stimuli not used in pretraining. Three of these classes were conditionally controlled by the B1 stimulus from the pretraining equivalence class, and three were controlled by the B3 stimulus. Phase 3 involved testing for the transfer of contextual control over equivalence classes through the pretraining equivalence classes. The six conditional equivalence classes trained during Phase 2 were tested using the C1 and C3 stimuli from the pretraining equivalence classes. Both the experimental and the control subjects were tested with the same C stimuli, although the control subjects had not had any prior experience with these stimuli. The trained and tested relations are depicted in Figure 4. The trials used in each phase are presented in Table 2.

*Procedure*

*Phase 1: Pretraining.* During Phase 1, all subjects received the match-to-sample training necessary to form three three-member equivalence classes. Subjects first were presented with the AB conditional discriminations (A1-B1, A2-B2, A3-B3). Each of these three pairs were presented randomly, six times each, in an 18-trial block. Comparison stimuli in each A-B trial consisted of all of the B stimuli (e.g., A1: B1, B2, B3). Subjects remained in A-B training until criterion was reached within a block of 18 trials. Following A-B training, A-C relations were presented until the subject reached criterion (A1-C1, A2-C2, A3-C3); control subjects were presented with A1-X1, A2-C2, and A3-X3 relations. These sets were then mixed and trained to criterion in blocks of 36 trials.

Experimental subjects then received a 36-trial symmetry test covering all B-A and C-A relations (e.g., B1: A1, A2, A3). If criterion was not reached, the subject repeated the mixed A-B/A-C training phase. Upon reaching criterion, the subject was presented with a 36-trial equivalence test on all B-C and C-B relations. Testing was conducted without feedback. If criterion was not met, subjects received additional A-B/A-C training followed by symmetry and then equivalence testing. The control subjects received the same procedure, except that X1 and X3 were used in place of C1 and C3.

*Phase 2: Establishment of conditional equivalence classes.* In Phase 2, subjects were presented with a total of 12 conditional discriminations, six of which appeared with the contextual stimulus B1 (hereafter referred to as CSB1) and six of which appeared with the contextual stimulus B3 (CSB3). In total, subjects received the training necessary to form three three-member equivalence classes in the presence of CSB1 and three three-member equivalence classes in the presence of CSB3.

*A-C training.* Subjects first were presented with the six conditional A-C discriminations—CSB1: A4-C4, A5-C5, A6-C6; and CSB3: A4-C6, A5-C4, and A6-C5. Thus, the C4, C5, and C6 stimuli changed class membership depending upon the contextual stimulus. Each A-C pair was presented randomly, six times, during a 36-trial block. Comparison stimuli consisted of all other C stimuli (e.g., CSB1: A4: C4, C5, C6). Upon reaching criterion, A-B training commenced.

*A-B training.* A-B relations were then similarly trained to criterion, although the B stimuli did not switch class membership when the contextual stimulus varied (i.e., CSB1 or CSB3: A4-B4, A5-B5, A6-B6). When criterion was reached, the subjects were then presented with A-B/A-C training.

*A-B/A-C training.* Subjects were then presented with 36-trial mixed blocks of all A-B/A-C relations. When criterion was reached, the subjects received a symmetry test.

*Symmetry test.* Subjects received a 36-trial symmetry test involving all B-A and C-A relations. If criterion was not met, the subjects received additional A-B/A-C training. When criterion was met, the subjects received an equivalence test.

*Equivalence test.* Subjects received a 36-trial equivalence test of all B-C and C-B relations under both contextual stimuli. If criterion was not met, mixed A-B/A-C training recommenced. Upon reaching criterion, the subjects advanced to Phase 3.

*Phase 3: Test for transfer of control over equivalence relations.* When conditional equivalence

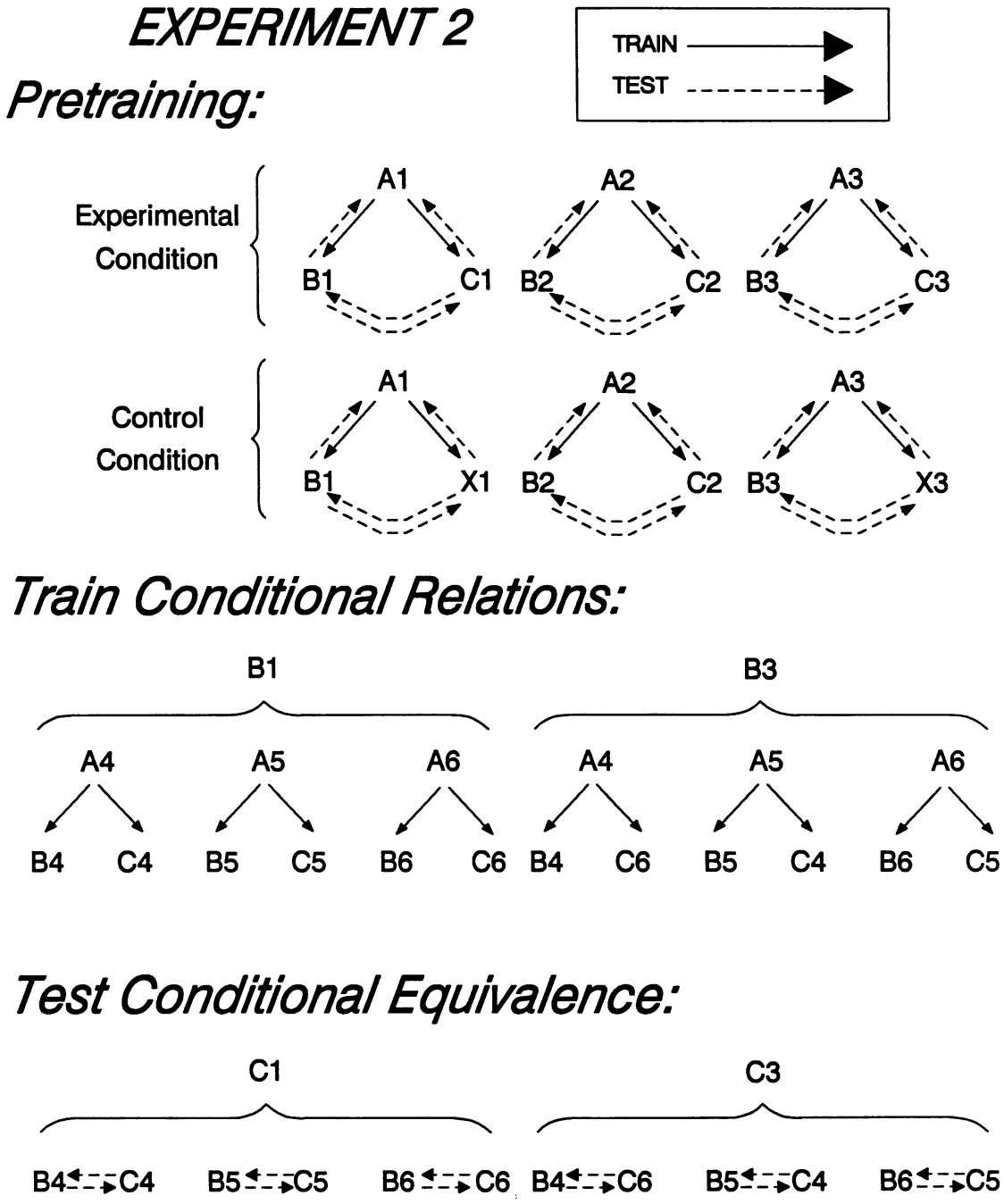


Fig. 4. A diagram of the procedure used in Experiment 2.

classes were shown under control of the B1 and B3 stimuli, the 36-trial equivalence test was repeated, now using the C1 and C3 stimuli as contextual stimuli. The control and experimental subjects were exposed to the same CSC1 and CSC3 stimuli, but the control subjects had had no previous experience with these stimuli.

Table 2

Experiment 2: training and testing trials. The correct comparison is the first stimulus to appear after the sample (the sample appears in bold face). The positions of the comparison stimuli were counterbalanced throughout all phases of the experiment.

| | | | | |
|---|---|---|---|---|
| Phase 1: pretraining experimental subjects | | | | |
| Conditional discrimination training | | | | |
| A-B relations: | | **A1**: B1 B2 B3 | **A2**: B2 B1 B3 | **A3**: B3 B1 B2 |
| A-C relations: | | **A1**: C1 C2 C3 | **A2**: C2 C1 C3 | **A3**: C3 C1 C2 |
| Mixed A-B, A-C training: All of the above trials were randomly presented. | | | | |
| Symmetry testing: All trials below were randomly presented. | | | | |
| B-A relations: | | **B1**: A1 A2 A3 | **B2**: A2 A1 A3 | **B3**: A3 A1 A2 |
| C-A relations: | | **C1**: A1 A2 A3 | **C2**: A2 A1 A3 | **C3**: A3 A1 A2 |
| Equivalence testing: All trials below were randomly presented. | | | | |
| B-C relations: | | **B1**: C1 C2 C3 | **B2**: C2 C1 C3 | **B3**: C3 C1 C2 |
| C-B relations: | | **C1**: B1 B2 B3 | **C2**: B2 B1 B3 | **C3**: B3 B1 B2 |
| Control subjects | | | | |
| Conditional discrimination training | | | | |
| A-B relations: | | **A1**: B1 B2 B3 | **A2**: B2 B1 B3 | **A3**: B3 B1 B2 |
| A-C relations: | | **A1**: X1 C2 X3 | **A2**: C2 X1 X3 | **A3**: X3 X1 C2 |
| Mixed A-B, A-C training: All of the above trials were randomly presented. | | | | |
| Symmetry testing: All trials below were randomly presented. | | | | |
| B-A relations: | | **B1**: A1 A2 A3 | **B2**: A2 A1 A3 | **B3**: A3 A1 A2 |
| C-A relations: | | **X1**: A1 A2 A3 | **C2**: A2 A1 A3 | **X3**: A3 A1 A2 |
| Equivalence testing: All trials below were randomly presented. | | | | |
| B-C relations: | | **B1**: X1 C2 X3 | **B2**: C2 X1 X3 | **B3**: X3 X1 C2 |
| C-B relations: | | **X1**: B1 B2 B3 | **C2**: B2 B1 B3 | **X3**: B3 B1 B2 |
| Phase 2: training experimental and control subjects | | | | |
| Conditional discrimination training | | | | |
| A-B relations: | CSB1: | **A4**: B4 B5 B6 | **A5**: B5 B4 B6 | **A6**: B6 B4 B5 |
| | CSB3: | **A4**: B4 B5 B6 | **A5**: B5 B4 B6 | **A6**: B6 B4 B5 |
| A-C relations: | CSB1: | **A4**: C4 C5 C6 | **A5**: C5 C4 C6 | **A6**: C6 C4 C5 |
| | CSB3: | **A4**: C6 C5 C4 | **A5**: C4 C5 C6 | **A6**: C5 C4 C6 |
| Mixed A-B, A-C training: All of the above trials were randomly presented. | | | | |
| Conditional equivalence testing: All trials below were randomly presented. | | | | |
| B-C relations: | CSB1: | **B4**: C4 C5 C6 | **B5**: C5 C4 C6 | **B6**: C6 C4 C5 |
| | CSB3: | **B4**: C6 C4 C5 | **B5**: C4 C5 C6 | **B6**: C5 C4 C6 |
| C-B relations: | CSB1: | **C4**: B4 B5 B6 | **C5**: B5 B4 B6 | **C6**: B6 B4 B5 |
| | CSB3: | **C4**: B5 B4 B6 | **C5**: B6 B5 B4 | **C6**: B4 B5 B6 |
| Phase 3: transfer of functions test | | | | |
| All above symmetrical and equivalence relations above were presented, but the contextual stimuli consisted of CSC1 and CSC3 instead of CSB1 and CSB3, respectively. | | | | |

Irrespective of the performance on this test, subjects were twice recycled through the mixed A-B/A-C training part of Phase 1, to Phase 2 and to Phase 3. This performance-independent recycling was done to ensure that the crucial Phase 3 test would not be influenced by the feedback possible in repeated retrainings. If the three Phase 3 tests were interrupted by a session break, additional recycling loops were added so that three Phase 3 tests could occur in a single session. Thus, all subjects were exposed to the transfer of control tests a minimum of three times.

## Results and Discussion

The results are shown in Figures 5 and 6 and Table 3. Conditional equivalence emerged quickly for most subjects—in the first Phase 2 test for 4 of the 6 primary subjects. The other 2 subjects required three Phase 2 tests before meeting criterion.

Phase 3 is the main test of interest because it assessed the transfer of contextual control over an equivalence class through an equivalence class. Considering only the last three Phase 3 tests for each subject, the 3 experi-

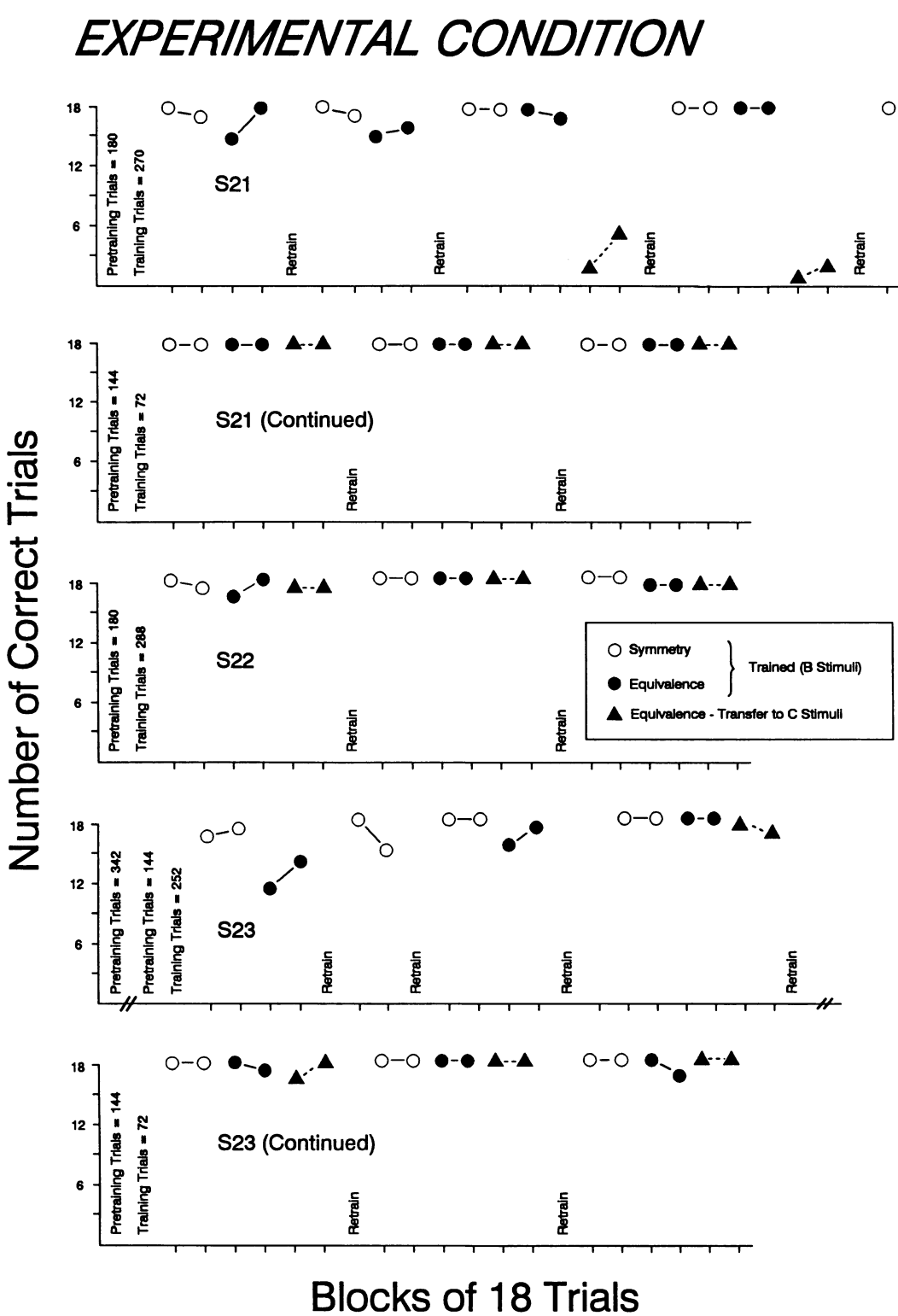


Fig. 5. The results for the Experimental Subjects 21 through 23. The open circles refer to the symmetry tests on the trained conditional equivalence classes, the closed circles to the equivalence tests for those classes, and the closed triangles to the symmetry and equivalence performance using the C stimuli.

Table 3

Number of problems correct in second-order conditionally controlled equivalence tests using the C stimuli (out of 36).

| Experimental condition | | | | | | Control condition | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Tests | | | | | | Tests | | |
| Subject | 1 | 2 | 3 | 4 | 5 | Subject | 1 | 2 | 3 |
| 21 | 7 | 1 | 36 | 36 | 36 | 27 | 0 | 7 | 6 |
| 22 | 34 | 36 | 35 | | | 28 | 12 | 18 | 36 |
| 23 | 33 | 34 | 36 | 36 | | 29 | 9 | 16 | 9 |
| 24[a] | 20 | | | | | 30[a] | 3 | | |
| | | | | | | 31[a] | 3 | | |
| *M*: | 23.5 | 23.6 | 35.6 | 36 | 36 | | 5.4 | 14.3 | 17 |
| Overall *M*: | | 30.94 | | | | | | 12 | |

[a] Subjects withdrew from the experiment (see text).

mental subjects met criterion on all nine of these tests (see Table 3 and Figure 5). Only 1 control subject met criterion, and in only one test.

Considering all subjects who took Phase 3 tests, even if they later withdrew from the study, experimental subjects responded correctly to 30.94 problems per 36-trial test overall, whereas the control subjects responded correctly at chance level (12 correct per 36 trials).

In general, performances tended not to vary from test block to test block. This is important because if the recycling served as negative feedback, responding would be expected to vary greatly. The relative consistency seen in subjects' performance in Experiment 2 supports our interpretation of the Experiment 1 results, despite the use of a contingent recycling procedure.

The results for the experimental subjects are shown in Figure 5. Subject 21 did not demonstrate the transfer of contextual control during his first two test blocks. Upon returning for a second session, however, he showed the transfer during three separate testing blocks. Subject 22 met criterion during each of three test blocks; Subject 23 met criterion during four test blocks over two sessions.

Control Subjects 27 through 29 were tested for conditional equivalence three times (see Figure 6). None of these subjects reached criterion during the first or second test, whereas 1 (S28) reached criterion during the third test. There was some tendency on the part of control subjects to treat the C stimuli as meaningful contextual cues, even though they had no experimental history with them. Most of the testing showed preferential responding in the presence of the C stimuli, but in only two cases (Test 1 with Subject 27 and Test 3 with Subject 28) were the preferences extreme, and some of the testing (e.g., Test 2 for Subject 28) showed no preferential responding. This kind of performance has been seen in previous transfer-of-function studies (S. Hayes et al., 1991). Subjects often seem to ascribe functions to novel stimuli based on the structure of the task at hand. This underlies the need for proper controls in transfer studies to distinguish the presence of general functions based on task structure and specific functions based on derived stimulus relations.

The present findings show that contextual control over equivalence classes can be transferred through other equivalence classes. Unlike previous research in this area (Gatch & Osborne, 1989), the transfer required an equivalence relation (derived B-C and C-B relations) to occur, because the only commonality between the B and C stimuli was their relation to the A stimuli established during pretraining.

## GENERAL DISCUSSION

The present experiments were designed to investigate whether an element of a class of arbitrarily related stimuli could acquire contextual control over equivalence relations, and whether that control would transfer, without direct training, to other members of the class. The data show that this kind of transfer can occur. Experiment 1 showed transfer across preexisting verbal classes. Experiment 2

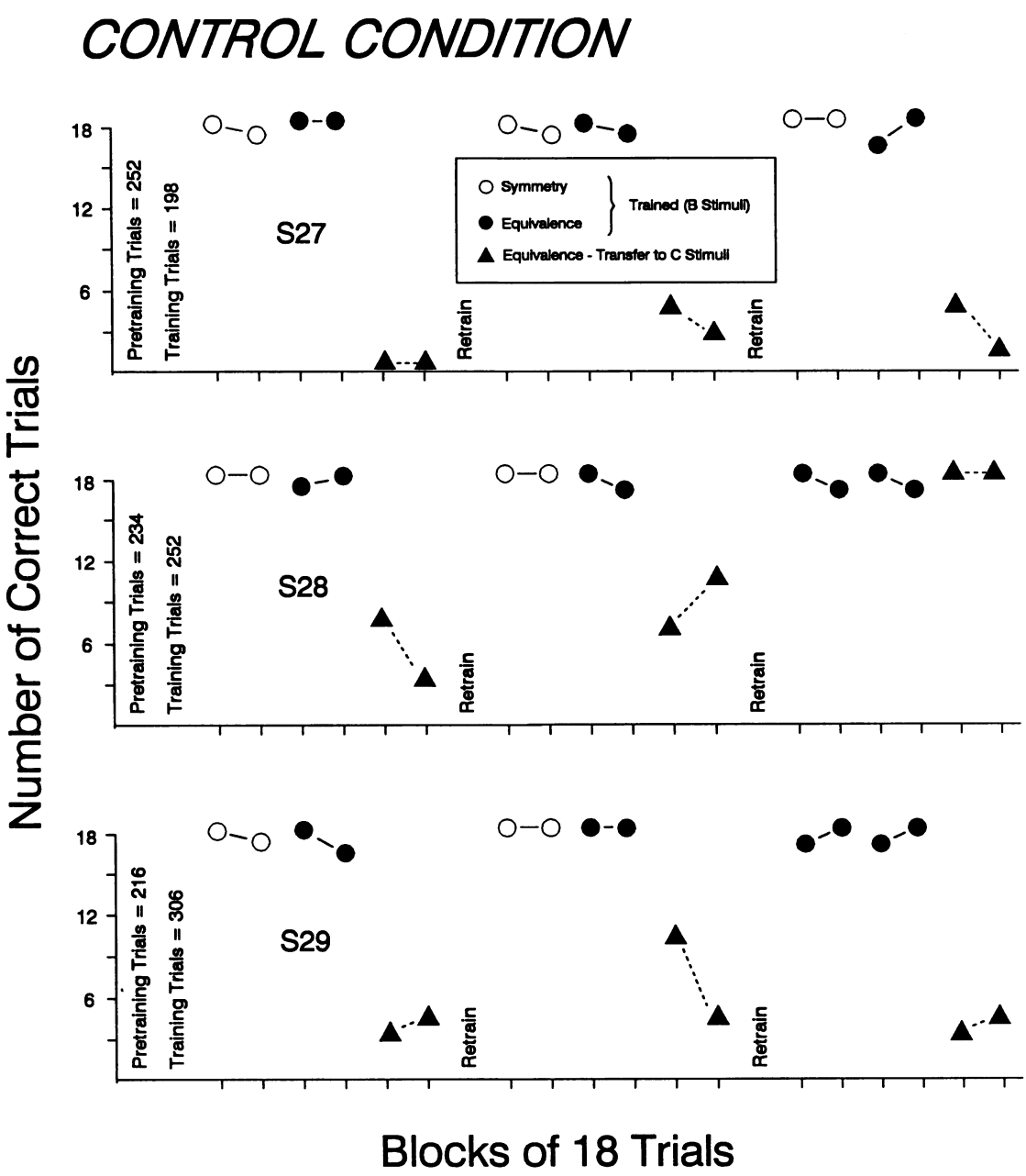


Fig. 6. The results for Control Subjects 27 through 29. The open circles refer to the symmetry tests on the trained conditional equivalence classes, the closed circles to the equivalence test for those classes, and the closed triangles to the symmetry and equivalence performance using the C stimuli.

showed transfer across experimentally established equivalence classes.

It could be argued that the results of Experiment 1 demonstrated a transfer of functions through functional classes, not equivalence classes, because common responses may have been previously trained in the presence of common male versus female names. There is little evidence that entirely new functions established to one member of a functional class will automatically transfer to other members. Specific functions have been shown to transfer

through functional classes (Sidman, Wynne, Macguire, & Barnes, 1989; Vaughan, 1988), but to date this has been shown to occur only when there is a direct reinforcement history for this transfer with those very functions (S. Hayes, 1989a). Such performance can be explained on the basis of directly established stimulus control. The relation between functional and equivalence classes is a complex issue, not yet well understood (S. Hayes, 1989a; Sidman et al., 1989; Vaughan, 1988, 1989). The issue is particularly difficult because functional classes can at times lead to equivalence relations in humans (Sidman et al., 1989; see also S. Hayes, 1989a). Whether via common trained responses or common stimulus relations, there can be little doubt that male and female names end up in a type of equivalence class for most, if not all, verbal humans.

To the extent that male and female names are in an equivalence class, Experiment 2 provides a basic process that could account for the results of Experiment 1. Experiment 2 provides the first unambiguous demonstration that control over the constitution of equivalence relations can transfer through equivalence relations.

The relevance of these findings to events existing outside of the laboratory are worth noting. Social stereotyping is involved in such problems as racial bigotry, religious wars, and sexual discrimination. Behavior-analytic research on social stereotyping has been minimal. The present method may provide a procedure for its examination.

The results underline the difficulties encountered in detecting and changing social stereotypes. Consider an example of racism. From the point of view of the reader, a newspaper story about a black person may literally mean something different than an identical story about a white person because the terms used in the story may sustain different verbal relations in the reader, under the contextual control of racial labels. Racial bigotry, in other words, need not be in the story itself for the story to strengthen racial bigotry.

Traditional behavior-analytic accounts of such phenomena might propose that they can be adequately described by appealing to an analysis based upon functional stimulus and response classes. These accounts are useful, but may not be complete, because they might not properly address the verbal elements of the phenomenon. A functional class analysis of social stereotyping would lead to a compelling discussion of how different stimuli become classed together via direct reinforcement histories, but the derived relations between those stimuli would not be adequately addressed. Equivalence accounts might offer a more complete description and analysis of the verbal elements involved in social stereotyping.

It remains to be seen whether an equivalence account might lead to more effective interventions than a functional class account. Equivalence accounts, for example, may lead one to propose that amelioration of social stereotyping may involve the alteration of contextual control over verbal relations in the reader. Or, perhaps knowing more about how to disrupt existing equivalence relations might prove to be useful. An analysis of the variables that control the failure to achieve equivalence might also be helpful. As yet, however, little is known about how contextual control over equivalence relations can be altered once it is established or how equivalence classes can be dissolved once they have formed, and our knowledge about the variables that control the failure to show equivalence is minimal. Research in these areas is needed.

The transfer of conditional control over derived stimulus relations is a behavioral process that may help explain such phenomena as semantic generalization, semantic networks, and network-based theories of meaning (Reese, 1991). Rather than place these derived relations inside the person in the form of hypothesized cognitive processes, the present study suggests they can be placed in the relational history of the organism brought to bear by available contextual cues.

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